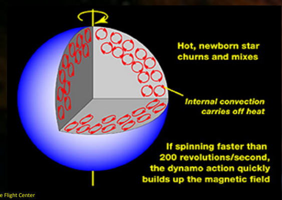
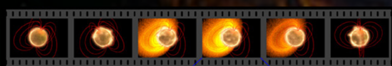
Time-Resolved Spectroscopy of 58 Bright Bursts from the Soft Gamma Repeater SGR J1550-5418

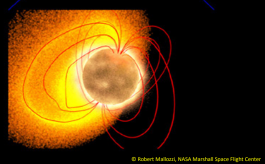
Nicholas Gorgone, Connecticut College and Samuel Grunblatt, Columbia University
Chryssa Kouveliotou, NASA/MSFC and Alexander van der Horst, USRA

What makes a magnetar?





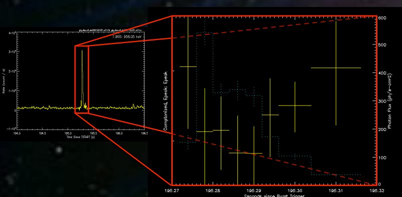
Magnetar Burst Sequence



1. Assignment

SGR J1550-5418 was observed with the Gamma-Ray Burst Monitor (GBM) onboard the Fermi satellite during a burst active episode in January 2009. In 7 days the source emitted over 350 bursts (van der Horst et al. 2011). *Our project was to perform time-resolved spectral analysis of 58 bright bursts from SGR J1550-5418 and study the distribution and evolution of their spectral parameters.*

2. Methodology



Sample Selection: We selected bursts with a flux > 5 x 10^{-6} erg/s/cm² or a fluence > 10^{-6} erg/cm² in the 8-200 keV energy range to allow good statistics for time-resolved analysis (following Lin et al. 2011). This resulted in a sample of 58 bursts.

Software Selection: For all spectral analysis we used the software package RMFIT *

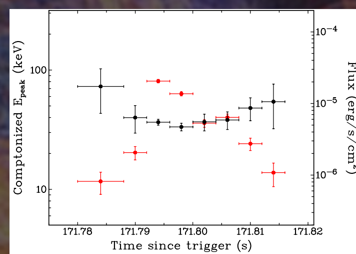
Time bin selection: We started with 4 ms binning and combined bins until the fit parameters were well constrained, i.e., until they had error bars comparable to the ones in the time bins with average brightness.

*Mallozzi, Briggs & Preece, "RMFIT, A lightcurve and Spectral Analysis Tool", © 2008.

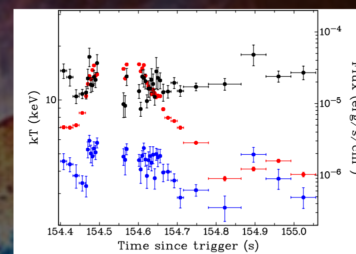
Abstract

Magnetars, slowly rotating neutron stars with tremendous magnetic fields (>10^{14} Gauss), are some of the most extreme objects in our Universe. Approximately twenty of these objects have been discovered to date. The sources are dormant most of their lifetimes, and become randomly active, emitting multiple soft gamma-ray bursts. Here we present our results from spectral analysis of bursts from the Soft Gamma Repeater SGR J1550-5418 emitted during a burst active episode between 2009 January 22 - 29. We have analyzed the 58 brightest bursts detected with the NaI (sodium iodide) detectors of the Gamma-ray Burst Monitor (GBM) on board the Fermi Observatory. We fit the time-resolved spectra of these bursts with three spectral models. We show the distributions and evolution of the temperature, peak energy, and surface area of emission derived using these models and discuss our results.

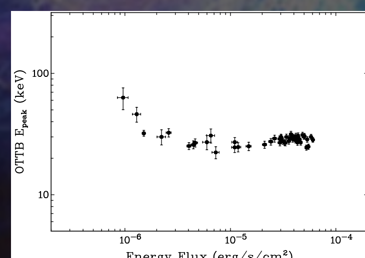
4. Results



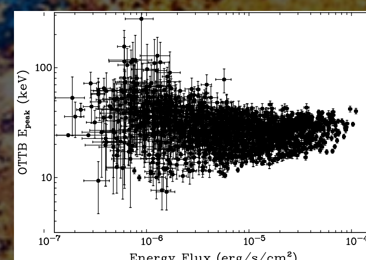
Burst 090122037.1: Evolution and anti-correlation of E_{peak} (black circles) with brightness using the Comptonized model. Event light curve is given in red circles.



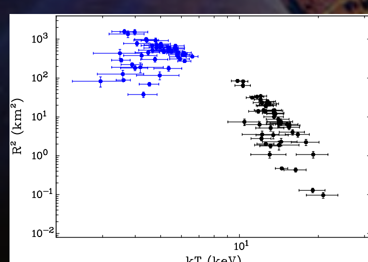
Burst 090122291.2: kT evolution and correlation with flux for 2BB (black and blue circles). Event light curve is given in red circles.



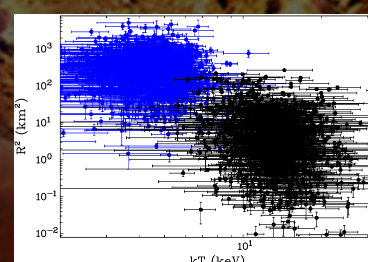
Burst 090122291.1: E_{peak} versus flux correlation using OTTB.



Same plot as the left panel for all 58 bursts.



Burst 090122291.1: Two distinct emitting areas during the same burst are seen with the 2BB model. Black and blue points represent the hot and cold black bodies, respectively.

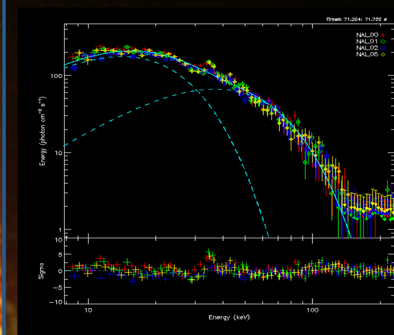


Same plot as the left panel for all 58 bursts. This result is in agreement with the time-integrated data from the same source presented in van der Horst et al. (2011).

Acknowledgements: We would like to thank Dr. Sylvain Guiriec for his assistance with IDL and the RMFIT software.

3. Analysis

We used the following models to fit each spectrum: Comptonized, two Black Bodies (2BB), and optically thin thermal bremsstrahlung (OTTB). In the Figure below we show the time-integrated spectrum using the 2BB model for one of the brightest bursts in our sample.



We collected and studied all parameters calculated by each model, namely temperature for OTTB, peak energy and spectral index for Comptonized, and temperatures and areas of the emitters for the 2BB. For each burst we also calculated the time-resolved energy fluxes and fluences with all three models. These parameter sets are displayed in the Results section and discussed in the Conclusions.

5. Conclusions

We have performed time-resolved spectral analysis for the 58 brightest bursts from SGR J1550-5418. The excellent temporal and spectral resolution afforded by GBM has enabled us to study magnetar bursts in a time-resolved manner over a broad spectral range (8-200 keV). We have used three different spectral models: OTTB, Comptonized and 2BB.

We find that the burst spectra can be described by a combination of a cool BB and a hot BB. The areas of these two components, estimated at the source distance of 5 kpc, follow different evolutionary tracks. The cool BB area varies between 10 – 1000 km², while the hot BB varies more dramatically between 0.01 – 100 km². Their temperature variation is 2-8 keV and 8-30 keV, respectively.

Using the Comptonized model, we can calculate the energy where the source emits most of its photons (E_{peak}). We found that this parameter is inversely proportional to the flux below a few times 10^{-6} erg/cm² s), but it remains constant with flux thereafter, in contrast to the time-integrated results for SGR J1550-5418 (van der Horst et al. 2011) and results reported for other magnetar sources (e.g., Lin et al. 2011).

Detailed spectral and timing studies of the current and future SGR bursts will further illuminate the mechanism behind the magnetar bursting behavior. We are currently exploring the classification of the bursts from SGR J1550-5418 into different subclasses depending on their spectral properties, which may reveal information on the involved mechanisms responsible for burst emission.